

CONCRETE STRUCTURES

510.1 GENERAL

Concrete structures, such as: bridges, culverts, storm inlets, retaining walls, abutments, piers, footings, foundations and similar structures, shall be constructed in conformity with these specifications and the construction plans.

510.2 REFERENCES

510.2.1 This Publication:

Section 101 Portland Cement Concrete
 Section 102 Steel Reinforcement
 Section 103 Epoxy-Coated Steel Reinforcement
 Section 105 Concrete Curing Compound
 Section 107 Joint Filler and Sealant Material
 Section 337 Portland Cement Concrete Pavement
 Section 349 Concrete Curing
 Section 501 Excavation and Backfill for Structures
 Section 502 Driving Piles

510.2.2 Others

PS-1-66 Specifications for Plywood, U.S. Products Standard, U.S. Department of Commerce.

Standard Specifications for Welding for Highway and Railroad Bridges, American Welding Society.

510.3 MATERIALS

510.3.1 CONCRETE

Concrete for use in work constructed under this section shall conform to the requirements of Section 101 and as shown on the plans or as specified in the Supplementary Technical Specifications and approved by the ENGINEER.

510.3.2 STEEL REINFORCEMENT

Reinforcement bars shall conform to the requirements specified in Section 102 and 103.

510.4 SUBGRADE FOR CONCRETE STRUCTURES

Earth subgrade upon which concrete is placed shall be firm and free from water and/or frost. All subgrade on which Structural concrete is to be placed shall be compacted to the minimum density specified in Section 501 or on the plans. Ground water shall be kept twelve (12") inches below the subgrade until the concrete has set. When the subgrade is in dry earth, it shall be moistened with water from a spray nozzle immediately before concrete is placed. When the design details for the project provide for the construction of filter or drain material consisting of gravel or combination of gravel and sand, which material becomes

subgrade for concrete, the placing of steel reinforcement and pouring of concrete shall follow the placing of the filter or drain material as closely as practical. The filter or drain material shall be kept dewatered to the extent necessary to prevent any portion of concrete materials being carried away before the concrete has attained its final set. When concrete is to rest on rock, the rock shall be fully uncovered. The surface of the rock shall be removed to a depth sufficient to expose sound rock. Bedrock shall be roughly leveled off or cut to approximately horizontal and vertical steps. Seams in the rock shall be grouted as directed by the ENGINEER and the base for structures shall be slush grouted or otherwise treated as the ENGINEER may direct.

510.5. FORMS

510.5.1 Forms shall be of suitable material and of type, size, shape, quality, and strength to enable construction as designed. The forms shall be true to line and grade, mortar tight, and sufficiently rigid to resist any appreciable amount of springing out of shape during placing of the concrete. The responsibility for their adequacy shall rest with CONTRACTOR. All dirt, chips, sawdust, nails, and other foreign matter shall be completely removed from forms before any concrete is deposited therein. The surfaces of forms shall be smooth and free from irregularities, dents, sags, and holes that would appreciably deface the finished surface. Forms previously used shall be thoroughly cleaned of all dirt, mortar, and foreign matter before being reused, and the reuse of forms shall be subject to approval of the ENGINEER. Before concrete is placed in forms, all inside surfaces of the forms shall be thoroughly treated with an approved releasing agent that will leave no objectionable film on the surface of the forms that can be absorbed by the concrete. Care shall be exercised that no releasing agent is deposited on previously placed concrete. Forms for all surfaces that will not be completely enclosed or hidden below the permanent surface of the ground shall be made of surfaced lumber or material which will provide a surface at least equally satisfactory. Any lumber or material which becomes badly checked or warped prior to placing concrete may be rejected. Forms for all exposed surfaces of bridges, viaducts, over crossings, and similar structures shall be constructed of plywood or an approved equal. Plywood for forms shall conform to the specifications of the U.S. Department of Commerce, U.S. Product Standard PS 1-66 Class I or II. All form panels shall be placed in a neat, symmetrical pattern with the horizontal joints level and continuous. Unless otherwise shown on the plans, all exposed edges shall have a 3/4 inch chamfer. Forms for curved surfaces shall be so constructed

and placed that the finished surface will not deviate appreciably from the arc of the curve. Forms shall be so constructed that portions, where finishing is required, may be removed without disturbing portions of form to remain. Form clamps or bolts approved by the ENGINEER shall be used to fasten forms. The use of twisted wire loop ties to hold forms in position will not be permitted, nor shall wooden spreaders be used unless authorized by the ENGINEER. Clamps or bolts shall be of sufficient strength and number to prevent spreading of the forms. They shall be of such type that they can be entirely removed or cut back 1 inch below the finished surface of the concrete. Forms for outside surfaces shall be constructed with stiff wales at right angles to the studs and all form clamps shall extend through and fasten such wales. The CONTRACTOR may, at his own option, place such portions of the concrete directly against the sides of the excavation or sheathing without the use of outside forms, provided that the following conditions are met:

510.5.1.2 If concrete is placed against sheathing, such sheathing shall be closely fitted and shall be outside of the concrete lines shown on the plans. Those surfaces against which the concrete is placed shall be faced with building paper. Except as otherwise specified hereinafter, all sheathing shall be removed but not until either at least 7 days after placing concrete or until the concrete has attained sufficient strength to support itself and any load that may be placed on it.

510.5.2 Care should be used in pulling sheathing so as to avoid damaging the concrete. Voids left by the removal of sheathing, piles, and/or similar sheathing supports shall be backfilled with material having a sand equivalent of not less than 30 and consolidated. When, in the opinion of the ENGINEER, field conditions or the type of sheathing or methods of construction used by the CONTRACTOR are such as to make the removal of sheathing impracticable, that portion of the sheathing against which concrete has been placed shall be left in place.

510.5.3 Regardless of the method used in placing concrete without outside forms, the following stipulations shall hold:

510.5.3.1 The reinforcing steel shall be accurately set and held firmly in place, to the satisfaction of the ENGINEER.

510.5.3.2 The CONTRACTOR shall assume all risks of damage to the work or to existing improvements due to any reason whatsoever that may be attributable to the method of construction outlined above.

510.5.3.3 Should the method of construction of placing directly against the sides of the excavation or sheathing without use of outside forms not prove satisfactory in the opinion of the

ENGINEER, the CONTRACTOR shall discontinue said method of construction and construct the structure by using outside forms.

510.6 FALSEWORK

All falsework shall be designed and constructed to provide the necessary rigidity and to support the loads. Falsework for the support of a superstructure shall be designed to support the loads that would be superimposed were the entire superstructure placed at one time. All falsework, staging, walkways, forms, ladders, cofferdams, and similar accessories shall equal or exceed the minimum applicable requirements of the Federal and State statutes and local ordinances. Compliance with such requirements shall not relieve the CONTRACTOR from full responsibility for the adequacy and safety of said items. Falsework shall be founded upon a solid footing safe against undermining and protected from softening. When the falsework is supported on timber piles, the piles shall be driven to a bearing value as determined by the formula specified in Section 502, equal to the total calculated pile loading. Falsework and forms shall be so constructed as to produce in the finished structure the lines and grades indicated on the plans. Suitable jacks or wedges shall be used in connection with the falsework to set the forms to grade or camber shown on the plans or to take up any settlement in the formwork either before or during the placing of the concrete. However, single wedges for this purpose will not be permitted, it being required that all such wedges be in pairs to insure uniform bearing. Dead load deflection in stringers and joists will be compensated for by varying the depth of the joists or by using varying depth nailing strips. Arch centering shall be removed uniformly and gradually beginning at the crown and working toward the springline to permit the arch to take its load slowly and evenly. Centering for adjacent arch spans shall be struck simultaneously. Falsework under any continuous unit or rigid frame shall be struck simultaneously, the supporting edges being released gradually and uniformly starting at the center and working both ways toward the supports.

510.7 REMOVAL OF FORMS

510.7.1 The falsework supporting any span of a continuous or rigid frame structure subject to bending stress shall not be released until after the last concrete placed in the span and in the adjoining spans (excluding concrete above the deck slab) has attained a compressive strength of not less than 80 percent of its design strength or 21 days after the concrete is placed, whichever occurs first. Stairway riser forms shall be removed and the finish of the steps completed on the day the concrete is poured. Metal stairway treads, if required by the plans, shall be installed immediately after the steps have

been poured. Forms and falsework supporting the bottom slab of the superstructure of box girder structures shall remain in place until the curing period of the deck of the superstructure has expired. Forms for the webs of box girders shall be removed before the deck slab is poured. Forms for the upper deck slab which are to remain in place shall be supported by bolts through the girder webs or some equally satisfactory method that will prevent the transfer of any load to the lower deck slab. Forms supporting the concrete deck slab of box girders may be left in place. All interior forms in box girders, except those permitted to remain in place, shall be completely removed and the inside of the box girder. Side forms for beams, girders, columns, railings, or other members wherein the forms do not resist dead load bending may be removed after a period of 36 hours, unless otherwise directed by the ENGINEER, provided that satisfactory arrangements are made to cure and protect the concrete thus exposed in accordance with Section 349. Side forms for arch rings, columns, and piers shall be removed before the members of the structure which they support are placed so that the quality of the concrete may be inspected. Such forms shall be so constructed that they may be removed without disturbing other forms which resist direct load or bending stress.

510.7.2 The periods of time at which the CONTRACTOR may remove forms, as set forth in this Section, are permissive only and subject to the CONTRACTOR assuming all risks that may be involved in such removals. At his option, the CONTRACTOR may leave the forms in place for such longer periods as are, in his opinion, required.

510.8 PLACING REINFORCEMENT

Reinforcing bars shall be accurately placed as shown on the plans and shall be firmly and securely held in position by wiring at intersections and elsewhere as necessary to prevent shifting of bars, with wire not smaller than No. 16, and by using concrete or metal chairs, spacers, metal hangers, supporting wires, and other approved devices of sufficient strength to resist crushing under full load. The use of wooden supports will not be permitted. Placing bars on layers of fresh concrete as the work progresses and adjusting bars during the placing of concrete will not be permitted. Before placing reinforcing steel in the forms, the reinforcing steel shall be thoroughly cleaned of mortar, oil, dirt, loose mill scale, loose or thick rust, and coatings of any character that would destroy or reduce the bonds. No concrete shall be deposited until the placing of the reinforcing steel has been inspected and approved.

510.9 SPLICING

Splices of bars shall be made only where shown on the plans or as approved by the

ENGINEER. Where bars are spliced, they shall be lapped at least 20 diameters for deformed bars, unless otherwise shown on the plans. Welding of reinforcing steel will be permitted when authorized by the ENGINEER in writing and shall be in accordance with the American Welding Society (Standard Specifications for Welding for Highway and Railroad Bridges).

510.10 BENDING REINFORCEMENT

Bends and hooks in bars shall be made in the manner prescribed by the American Concrete Institute. Bars shall not be bent nor straightened in a manner that will injure the material. Bars with kinks or unspecified bends shall not be used.

510.11 WELDED WIRE FABRIC

Welded wire fabric shall be held firmly in place. Welded wire fabric shall be spliced not less than two meshes.

510.12 PLACING CONCRETE

510.12.1 Where a schedule for placing concrete is shown on the plans, no deviation will be permitted therefrom unless approved in writing by the ENGINEER. The placing of concrete for a given area shall start at the low point and shall proceed up grade, unless otherwise permitted by the ENGINEER. With the exception of concrete placed in slope paving and aprons and concrete placed under water, all concrete shall be compacted by means of high frequency internal vibrators of a type, size, and number approved by the ENGINEER. The number of vibrators employed shall be ample to consolidate the incoming concrete to a proper degree within 15 minutes after it is deposited in the forms. In all cases, at least 2 vibrators shall be available at the site of the structure in which more than 25 cubic yards of concrete is to be placed. The vibrators shall not be attached to or held against the forms or the reinforcing steel. The locations, manner, and duration of the application of the vibrators shall be such as to secure maximum consolidation of the concrete without causing segregation of the mortar and coarse aggregate and without causing water or cement paste to flush to the surface. Fresh concrete shall be spread in horizontal layers insofar as practicable, and the thickness of the layers shall not be greater than can be satisfactorily consolidated with the vibrators. If additional concrete is to be placed, care shall be taken to remove all laitance and to roughen the surfaces of the concrete to insure that fresh concrete is deposited upon sound concrete surfaces. Layers of concrete shall not be tapered off in wedge-shaped slopes but shall be built with square ends and level tops.

510.12.2 Mixed concrete, after being deposited, shall be consolidated until all voids are filled and free mortar appears on the surface. The concrete shall be placed as nearly as possible in its final position.

The use of vibrators for extensive shifting of the mass of fresh concrete will not be permitted. Fresh concrete shall not be permitted to fall from a height greater than 6 feet without the use of adjustable length pipes or "elephant trunks" or "Trimmies." The use of approved external vibrators for compacting concrete will be permitted when the concrete is inaccessible for adequate compaction, provided the forms are constructed sufficiently rigid to resist displacement or damage from external vibration. During the placing of concrete, care shall be taken that methods of consolidation used will result in a surface of even texture free from voids, water, or air pockets and that the coarse aggregate is forced away from the forms in order to leave a mortar surface. Spades or broad-tined forks shall be provided and used to produce the desired results if required by the ENGINEER. The use of chutes in conveying or depositing concrete will be allowed only at the discretion of the ENGINEER; and wherever they are used, they shall be laid at such inclination as will permit the flow of concrete of such consistency as is required. The use of additional water in mixing the concrete to promote free flow in chutes of low inclination will not be allowed. Where necessary in order to prevent segregation, chutes shall be provided with baffle boards or a reversed section at the outlet. Columns shall be poured preferably through pipes of adjustable length and not less than 6 inches in diameter. Horizontal members or sections shall not be placed until the concrete in the supporting vertical members or sections has been consolidated and settlement has occurred.

510.13 JOINTS

The work shall be so prosecuted that construction joints will occur at designated places shown on plans unless specifically permitted otherwise by the ENGINEER. The CONTRACTOR shall complete, by continuous depositing of concrete sections of the work comprised between such joints. The joints shall be kept moist until adjacent concrete is placed. All construction joints at the bottom of walls or arches, at the top of walls, and all longitudinal construction joints having a keyed, stepped, or roughened surface shall be cleaned by sandblasting prior to pouring the adjacent concrete. Any quality of sand may be used which will accomplish the desired results. Other methods of cleaning joints may be used provided the method and result is approved by the ENGINEER. Joint cleaning operations shall be continued until all unsatisfactory concrete and all laitance, coatings, stains, debris, and other foreign materials are removed. The surface of the concrete shall be washed thoroughly to remove all loose material. The method used in disposing of waste water employed in washing the concrete surfaces shall be such that the waste water will not stain, discolor, or affect exposed surfaces of the structure. The method of disposal

will be subject to the approval of the ENGINEER. All horizontal construction joints or those on slight slopes shall be covered with mortar. Expansion and contraction joints in the concrete structures shall be formed where shown on the drawings and as directed by the ENGINEER. In general, such joints shall have smooth abutting surfaces, painted, or separated and sealed in accordance with Section 107 or as detailed on the plans. No reinforcement shall be extended through the joints, except where specifically noted or detailed on the plans.

510.14 PLACING CONCRETE UNDER ADVERSE WEATHER CONDITIONS

Concrete for structures shall not be placed on frozen ground nor shall it be mixed or placed while the ambient temperature is below 40°F. Concrete shall not be placed during rainfall unless adequate protection is provided. Upon written notice from the ENGINEER, all concrete which may have become damaged due to adverse weather conditions, shall be replaced by the CONTRACTOR at no expense to the OWNER.

510.15 SURFACE FINISHES

The classes of surface finish described hereafter shall be applied to various parts of concrete structures as specified. Bridge decks shall be finished in conformity with Section 337. When required by the ENGINEER, the CONTRACTOR, prior to placing of concrete, shall provide a test section for evaluation of the surface finish to be employed. There will be no separate payment made for the test sections.

510.15.1 ORDINARY SURFACE FINISH

510.15.1.1 Immediately after the forms have been removed, all exterior form bolts shall be removed to a depth of at least 1 inch below the surface of the concrete and the resulting holes or depressions cleaned and filled with mortar, except on the interior surfaces of box girders the bolts shall be removed flush with the surface of the concrete. Mortar shall consist of 1 part by volume of cement to 2 parts of sand. Mortar shall be mixed approximately 45 minutes in advance of use. Care shall be exercised to obtain a perfect bond with the concrete. After the mortar has thoroughly hardened, the surface shall be rubbed with a carborundum stone in order to obtain the same color in the mortar as in the surrounding concrete. All fins caused by form joints and other projections shall be removed and all pockets cleaned and filled. Mortar for filling pockets shall be treated as specified for bolt holes.

510.15.1.2 In the judgment of the ENGINEER, if rock pockets or other defects are of such extent or character as to affect the strength of the structure materially or to endanger the life of the steel reinforcement, he may declare the concrete defective and require the removal and replacement of the structure affected.

510.15.1.3 Ordinary Surface Finish shall be applied to all concrete surfaces either as a final finish or preparatory to a higher class finish. Ordinary Surface Finish, unless otherwise specified, shall be considered as a final finish on the following surfaces:

510.15.1.3.1 The undersurfaces of slab spans, box girders, filled spandrel arch spans, and floor slabs between T girders or superstructures not for grade separation structures.

510.15.1.3.2 The inside vertical surface of T girders or superstructure not for grade separation structures and the exposed surfaces of channel walls.

510.15.1.3.3 Surfaces which are to be buried underground or covered with embankment and surfaces above finished ground of culverts where not visible from the traveled way.

510.15.1.4 On surfaces which are to be buried underground or surfaces which are completely enclosed, such as the cells of box girders, the removal of fins and form marks and the rubbing of mortared surfaces to a uniform color will not be required.

510.15.2 CLASS 1 SURFACE FINISH

510.15.2.1 After completion of the Ordinary Surface Finish, the entire surface specified shall be sanded with a power sander or other approved abrasive means as required to obtain a uniform color and texture. The use of power carborundum stones or discs will be required to remove unsightly bulges or irregularities. The Class 1 Surface Finish shall be applied after the removal of forms. The object of these operations is to obtain a smooth, even surface of uniform appearance and to remove unsightly bulges or depressions due to form marks and other imperfections. The degree of care in building forms and the character of materials used in formwork will be a contributing factor in the amount of such sanding and grinding requirement, and the ENGINEER shall be the sole judge in this respect.

510.15.2.2 Class 1 Surface Finish as hereinafter specified shall be applied to the following surfaces unless otherwise specified in the Supplementary Technical Specifications.

510.15.2.2.1 All surfaces of superstructures for grade separation structures.

510.15.2.2.2 All exposed surfaces of bridge piers, columns and abutments, and retaining walls and to at least 1 foot below finished grade.

510.15.2.2.3 The outside vertical surfaces and bottom surface of outside girders and the under surfaces of cantilever sidewalks, safety curbs, and floor slabs overhanging

outside girders only of superstructures not for grade separation structures.

510.15.2.2.4 All surfaces of open spandrel arch rings, spandrel columns, and abutment towers.

510.15.2.2.5 Exposed surfaces of culvert headwalls and retaining walls, where visible from a traveled way.

510.15.2.2.6 Surfaces inside of culvert barrels having a height of 4 feet or more for a distance inside the barrel at least equal to the height of the culvert.

510.15.2.2.7 All interior surfaces of pump house motor and control rooms and engine generator rooms.

510.15.3 CLASS 2 SURFACE FINISH

Class 2 Surface Finish as hereinafter specified shall be applied to the following surfaces unless otherwise specified in the Supplementary Specifications: all surfaces of concrete railing, including barrier railing, rail posts, rail end posts, and rail base. When Class 2 Surface Finish is specified, the Ordinary Surface Finish and Class 1 Surface Finish shall be completed in succession. The process specified under Class 2 Surface Finish shall then be deferred until all other work, which would in any way affect or mar the final finish, is complete. The CONTRACTOR shall then apply a brush coat or surface film of thin cement mortar composed of 1 part Portland cement and 1 part of fine sand of such size that it will pass a No. 16 sieve or, at the option of the ENGINEER, a neat cement wash. In either case, an amount of calcium chloride equal to 5 percent by volume of the cement shall be used in the brush coat. When the cement film has set sufficiently so that the sand particles or cement will not drag out of surface pin but before the final set has taken place, the entire surface shall be thoroughly rubbed either by hand or by mechanical means with fine carborundum stone until a smooth surface of even texture, color, and appearance is obtained. No greater amount of mortar shall be applied in advance of rubbing than can be completely rubbed before final setting takes place. Immediately following the rubbing process, the finished surface shall be thoroughly washed with water.

510.16 CURING

Immediately after the completion of the finishing operations as the condition of the concrete will permit without danger of consequent damage thereto, the CONTRACTOR shall initiate the curing of the concrete as specified in Section 349 and/or as approved by the ENGINEER.

510.17 TESTS

Testing procedures shall be as provided for in Section 101. The number of test

specimens to be taken for compression tests shall be as specified in Section 101 or as otherwise required by the ENGINEER.

510.18 MEASUREMENT: Structural Concrete for Concrete Structures shall be measured by the cubic yard or as part of a lump sum item as indicated in the Bid Proposal.

510.18.2 PAYMENT: The payment for Structural Concrete shall be at the contract unit price per cubic yard or lump sum, complete in place. Payment shall include all material, equipment and labor required in forming, supporting, placing, finishing, curing, form and support removal, and cleanup.